Reminder: *We need to develop a response to the following summary of the public comments received on landslides. We need to make sure we strengthen our rationale to address any apparent weaknesses the public pointed out in our proposed findings.*

Comment: *Some commenters acknowledged that landslides caused by logging practices such as clear cutting are a real problem in Oregon and additional management measures are necessary to address these impacts. It was noted that Oregon does not have sufficient programs in place to control non-point pollution from forestry practices, particularly due to logging on private lands.*

Others expressed their disagreement with the federal agencies' recent decision and argued that the evidence provided by the federal entities was misleading, only focusing on "landslide density relationships" rather than considering the "total number of landslides triggered during major storms". If consider the latter, one would see that the "potential increases in sediment delivery to public resources from landslides...is proportionally small". In addition, it was argued that EPA has not offered objective evidence that additional management measures are needed to maintain water quality. It was recommended that EPA consider a broader scale view over longer timeframes to evaluate whether water quality and designated uses are impaired. The commenter added that the federal agencies have not produced any evidence that landslides resulting from forest management activities have caused exceedances in water quality or negatively impacted aquatic life.

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Forestry - Landslide Rationale

Oregon proposes to address this element of the additional management measures for forestry condition through a mix of regulatory and voluntary approaches. While the state has adopted more protective forestry rules to reduce landslide risks to life and property and promotes some voluntary practices to reduce landslide risks through the Oregon Plan for Salmon and Watersheds (The Oregon Plan), Oregon still does not have additional management measures for forestry in place to protect high-risk landslide areas to ensure that water quality standards and designated uses are achieved.

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Since receiving conditional approval on January 13, 1998, Oregon amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction and placed certain restrictions on harvest and road activities within these designated high-risk landslide areas for public safety (OAR 629-623-0000 through 629-623-0800). However, under these amendments, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for losses of life and property, not for potential water quality impacts. Oregon still allows timber harvest and the construction of forest roads, where alternatives are not available, on high-risk landslide hazard areas as long as it is not deemed a public safety risk.

In addition to these regulatory programs, Oregon employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide-prone areas as a source of large wood. The large wood, which may eventually be deposited into fishbearing stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery. While this is a good management practice, the measure is not designed to protect high-risk erosion areas but rather to ensure large wood is available to provide additional stream complexity when a landslide occurs.

As noted in the January 13, 1998, findings, timber harvests on unstable, steep terrain can result in increases in landslide rates which contribute to water quality impairments. A number of studies continue to show significant increases in landslide rates after clear cutting compared to unmanaged forests in the Pacific Northwest. For example, Robinson et al. (1999) found that in three out of four areas studied in very steep terrain, landslide densities and erosion volumes were greater in stands that were clear-cut during the previous nine years.[1]
Research by Montgomery et al. (2000), and Turner et al. (2010) is also consistent with this finding that timber harvest increases landslide rates. Montgomery et al. (2000) concluded that landslide rates in Mettman Ridge in the Oregon Coast Range increased after clear cutting at a rate of three to nine times the background rate for the region. The regional analysis from the Mettman Ridge study found that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest.[2] Turner et al. (2010), also found that rain fall intensity, slope steepness, and stand age contributed to landslide rates. Very few landslides occurred when rainfall was less than or equal to a 100-year rainfall event and at higher rainfall intensities, steep slopes had significantly higher landslide densities compared to lower gradient slopes. In addition, they found that at higher rainfall intensities, the density of landslides in recently harvested sites was roughly two to three times the landslide density in older stands.[3]

Other research has examined the role of root cohesion on landslide susceptibility in forested landscapes. Root cohesion is a measure of the lateral reinforcing strength the root system provides.[4] The higher the root cohesion, the better the root system can stabilize the soil, reducing the risk of landslides. Schmidt et al. (2001) found that median lateral root cohesion is less for industrial forests with significant understory and deciduous vegetation (6.8–23.2 kPa) compared to natural forests dominated by conifers (25.6–94.3 kPa). In clearcuts, Schmidt et al. found that lateral root cohesion is uniformly less than or equal to 10 kPa, making these areas much more susceptible to landslide.

Sakals and Sidle (2004) modeled the effect of different harvest methodologies on root cohesion over time.[5] They found that, of the methodologies examined, (clear cutting, single tree selection cutting and strip cutting), clear cutting produces the greatest decline in root cohesion. Further, they found that root cohesion may continue to decline for 30 years post-harvest. That decline is attributed to the decay of the root systems of the harvested trees, and the fact that young root systems have smaller root volumes and less radial rooting extent. They concluded that clear

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[1]Robison, G.R., Mills, K.A., Paul, J. Dent, L. and A. Skaugset. 1999. Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report. Oregon Department of Forestry Forest Practices Monitoring Program. Forest Practices Technical Report Number 4.157 pages.

[2] Montgomery, D. R., K. M. Schmidt, H. M. Greenberg & W. E. Dietrich, 2000. Forest clearing and regional landsliding. Geology 28: 311–314.

[3] Turner, T.R., Duke, S.D., Fransen, B.R., Reiter, M.L., Kroll, A.J., Ward, J.W., Bach, J.L., Justice, T. E., and R.E. Bilby. 2010. Landslide densities associated with rainfall, stand age, and topography on forested landscapes, southwestern Washington, USA. Forest Ecology and Management 259 (2010) 2233–2247

[5]Sakals, M.E. and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. Canadian Journal of Forest Research 34(4): 950-958.

cutting on hazard slopes could increase the number of landslides as well as the probability of larger landslides. They also stated that a management approach requiring the retention of conifers on high-risk slopes would increase root cohesion and reduce the risk of landslide.

Not only has the science demonstrated that timber harvesting can contribute to landslides but that these landslides also degrade water quality and impair designated uses in Pacific Northwest streams. In a 2012 paper, Whittaker and McShane cited that:

> "In the Pacific Northwest, … Landslides alter aquatic habitats by elevating sediment delivery, creating log jams, and causing debris flows that scour streams and stream valleys down to bedrock (Rood, 1984; Cederholm and Reid, 1987; Hogan et. al., 1998). The short-term and long-term impacts of higher rates of landslides on fish include habitat loss, reduced access to spawning and rearing sites, loss of food resources, and direct mortality (Cederholm and Lestelle, 1974; Cederholm and Salo, 1979; Reeves et. al., 1995). The restoration of geomorphic processes to natural disturbance regimes is crucial to the recovery of endangered salmonids (*Oncorhynchus* spp.) and other aquatic species in the Pacific Northwest as these species evolved under conditions with much lower sediment delivery and landslide frequency (Reeves et. al., 1995; Montogomery, 2004)."

In 2013, the Cooperative Monitoring Evaluation and Research committee (CMER) of the Washington State Department of Natural Resources published a study that explored landslide response to a large 2007 storm in Southwestern Washington.[6] Within the 91 square mile study area, a total of 1147 landslides were found within harvest units that delivered to public resources (mostly streams). The majority (82%) occurred on hillslopes and the rest initiated from roads. In examining these landslides, the study found that unstable hillslopes with no buffer had a significantly (65%) higher landslide density than did mature stands. Unstable slopes with no buffer also delivered 347% more sediment than slopes with mature stands. The authors conclude that buffers on unstable slopes likely reduce landslide density and sediment volume. This has important implications for water quality and beneficial uses. It is well documented that sediment can clog and damage fish gills, suffocate fish eggs, smother aquatic insect larvae, and fill in spaces in streambed gravel where fish lay eggs. Sediment can also carry other pollutants into waterbodies, creating issues for domestic water supply and public water providers.

In northern California, the North Coast Regional Water Quality Board is currently developing a TMDL to address water quality impairments due to sedimentation in the Elk River watershed. Landslides were identified as a major source of sediment in the North Fork of the river. The main causes of these landslides were: poorly located, constructed, or maintained roads; logging with ground-based systems on steep slopes; harvesting on inherently unstable slopes; temporary reduction in root strength from clear cutting; and legacy problems associated with old skid trails and abandoned roads. [7]This TMDL demonstrates how landslides from anthropogenic activities have contributed directly to water quality degradation.

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[6] Stewart, G., Dieu, J., Phillips, J., O'Connor, M., Veldhuisen C., 2013. The Mass Wasting Effectiveness Monitoring Project: An examination of the landslide response to the December 2007 storm in Southwestern Washington; Cooperative Monitoring, Evaluation and Research Report CMER 08- 802; Washington Department of Natural Resources, Olympia, WA.

[7] Stillwater Sciences,2007. Landslide Hazard in the Elk River Basin, Humboldt County, California, June 2007

There is abundant evidence that shows clear-cutting increases the rate of landslides and that landslides that reach water bodies? ~~can e~~adversely affect water quality and beneficial uses. Additional management measures are needed to ~~provide greater~~ increase protection of water quality in waters in landslide prone areas ~~for the protection of water quality~~ in Oregon. In order to meet water quality standards ~~To meet this~~with additional management measures for landslide prone areas ~~requirement~~, the ~~s~~State could do some or all of the following (though the State retains full discretion in how it chooses to act):

- Adopt ~~similar~~ harvest and road construction restrictions similar to those applicable in areas where landslides pose risks to life and property, but for all high-risk landslide prone areas with the potential to impact water quality and designated uses~~, not just those areas where landslides pose risks to life and property.~~

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- Develop a scientifically rigorous ~~peer-reviewed~~ process for identifying high-risk areas and unstable slopes based on field review by trained staff. Such a ~~That~~ process could include the use of slope instability screening tools to ~~that help~~ identify high-risk landslide areas that take into account site-specific factors such as slope, geology and geography and planned land management activities, such as roads development.

- Develop more robust voluntary programs to encourage and incentivize the use of forestry best management practices to protect high-risk landslide areas that have the potential to impact water quality and designated uses, such employing no-harvest restrictions around high-risk areas and ensuring that roads are designed, constructed, and maintained in such a manner that the risk of triggering slope failures is minimized. ~~Make~~ Widely available maps of ~~all~~ high-risk landslide areas ~~widely available to~~ could improve water quality by informing foresters ~~to inform~~ during harvest planning.

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- Institute a monitoring program to track compliance with the FPA rules and voluntary guidance for high-risk landslide prone areas and the effectiveness of these practices in reducing slope failures.

- Establish an ongoing monitoring program that adequately assesses cause and effects of recent landslides and ~~has~~generates specific recommendations for future parcel management. In particular, look for ways to reduce the occurrence of channelized landslides.

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- Integrate processes to identify high-risk landslide prone areas and specific best management practices to protect these areas into the TMDL development process. For example, in the Mid-Coast Basin, DEQ is currently developing a sediment TMDL to address water quality limited waters for biocriteria, turbidity, and sediment. To support the development of the TMDL, the Oregon Department of Geology and Mineral Resources completed landslide inventory maps for two watersheds in the Mid-Coast Basin finding hundreds of previously unidentified landslides.[8] As part of the TMDL DEQ ~~will~~would be completing a source assessment of the landslides in relationship to the

[8] Burns, W. J., Duplantis, S., Jones, C., English, J., 2012. LIDAR Data and Landslide Inventory Maps of the North Fork Siuslaw River and Big Elk Creek Watersheds, Lane, Lincoln and Benton Counties, Oregon. Open-File Report O-12-07, Oregon Department of Geology and Mineral Industries.

water quality impairments. NOAA and EPA encourage the ~~s~~State to complete this TMDL and include specific practices ~~that~~specific landowners ~~will need~~ to follow in order to ~~address the issue~~reduce the pollutants causing impairments addressed in the TMDL implementation plans.

If the Oregon plans to rely on voluntary efforts, the ~~s~~State ~~must~~would need to describe the full suite of voluntary practices it plans to use address this management measure, how the ~~s~~State ~~will~~would promote these voluntary practices, and meet the other requirements when using voluntary programs to meet 6217(g) management measure requirements (i.e., a legal opinion asserting the state has back-up authority to ensure implementation of the management measure, a commitment to use the back-up authority, and a description of the monitoring and tracking program the state will use to assess how it will monitor and track implementation of the voluntary approach).

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